

We claim:

1. A method of decentralized medium access control in a communications network (300) including a plurality of devices (301), comprising the steps of:

dividing time into a sequence of at least one superframe (100); and

a first device (301) of said plurality transmitting in the superframe (100) at a target beacon transmission time (TBTT) (201) a beacon frame (400) that includes a reservation for a planned transmission by a sender device (301) during the superframe.

2. The method of claim 1, wherein:

said first device (301) is the sender (301) of said planned transmission; and

further comprising the steps of –

- a. the sender (301) including the reservation in a beacon frame (400) in all superframes (100) during which the reservation is active, and
- b. including, by a receiver device (301) of the planned transmission, said reservation in a beacon frame (400) in all superframes (100) during which the reservation is active.

3. The method of claim 1, further comprising the step of grouping the beacon frame (400) transmitted by each of the plurality of devices (301) into the superframe (100) as at least one beacon period (101) having a starting point at a beacon period start time (BPST) (201) and followed by a data transmission phase (102).

4. The method of claim 1, further comprising the step of prior to a new or a change of an existing reservation of the sender device (301), the sender device (301) negotiating with a receiver device (301) of the transmission that is planned during the reservation.

5. The method of claim 4, said negotiation step comprising the steps of:

an initiator device (301) of the reservation transmitting a distributed reservation protocol (DRP)-Request message (1000) comprising at least one reservation description selected from the group consisting of

a starting time, and a duration signalled by means of BPST or TBTT offset (705) (711),

a reservation period (710),

a bitmap indicating the reserved times (706) (708) (712),
at least one time slot number,
a priority (804),
a channel/hopping indicator (806), and
a code sequence; and

in response to said DRP-Request, said negotiation step further comprises the step of at least one receiver device (301) of the reservation transmitting a distributed reservation protocol (DRP)-Response message (1100) that includes an indicator (1104) selected from the group consisting of the proposed reservation is accepted, the proposed reservation is rejected with an alternative reservation proposal (1105) and the proposed reservation is rejected without an alternative proposal.

6. The method of claim 5, wherein the negotiation step further comprises the step of said at least one receiver device further including in said DRP-Response (1100) one of the items selected from the group consisting of at least one alternative available time proposal for the reservation and information of at least one alternative available time during the superframe (1105).

7. The method of claim 1, further comprising the step of including in the beacon frame (400) of the first device (301) a starting time of the reservation relative to a reference point (705) (711) selected from the group consisting of the TBTT (201) of the first device (301), the BPST (201) of the beacon period in which the first device (301) is transmitting the beacon frame (400), the beginning of the superframe (205), a time period of the superframe (100), and a time slot of the superframe (205).

8. The method of claim 7, wherein:

the starting time of the reservation is given relative to said reference point (705) (711) in the next following superframe (206), in which said first device (301) will transmit its next beacon frame (400); and

if proposed by the receiver device, the at least one alternative available time for the reservation is given relative to a reference point (705) (711) in the next following superframe (206), in which said receiver device will transmit its next beacon frame (400).

9. The method of claim 1, further comprising the step of maintaining by each device of said plurality a table of all planned reservations (306) received or sent by the device.

10. The method of claim 1, further comprising the steps of:
a receiver device (301) of said reservation sending a poll packet to the sender device (301);
upon receipt of the poll packet, the sender device (301) sending at least one data packet to the receiver device (301); and
the receiver device (301) acknowledging receipt of at least one data packet by transmitting an acknowledgement (ACK) packet.

11. The method of claim 1, further comprising the steps of:
defining said superframe as comprising a plurality of medium access time slots; and
defining a reservation as a starting time slot (705) (711) of said plurality of medium access time slots and a duration (706) (712) as a number of medium access time slots.

12. The method of claim 1, further comprising the step of:
defining said superframe as comprising a plurality of time units; and
defining a reservation as a starting time in time units (705) (711) and a duration (706) (712) as a number of time units.

13. The method of claim 1, further comprising the steps of:
defining said superframe as comprising a plurality of medium access time slots; and
defining a reservation as at least one bit in a bitmap (708) (712) comprising at least one bit per each medium access time slot of said plurality of medium access time slots.

14. The method of claim 1, further comprising the steps of:
defining said superframe as comprising a plurality of medium access time slots; and
defining a reservation as at least one element selected from the group consisting of a reservation period (705) (710), a reservation offset (705) (711), a reservation period offset (705) (710) (711), a reservation duration, a bitmap (706) (712) of at least one medium access time slot and a type of reservation (709).

15. The method of claim 1 further comprising the step of defining a reservation as one element selected from the group consisting of:

- a plurality of reservations per superframe (100) and valid for a single superframe (100),
- a plurality of reservations per superframe (100) and valid for a plurality of superframes (100),
- single reservation per superframe (100) and valid for a single superframe (100), and
- single reservation per superframe (100) and valid for a plurality of superframes (100).

16. The method of claim 6, wherein said at least one alternative available time for the reservation is signalled by means of an availability bitmap (1105) having at least one bit per time slot to indicate the availability of the time slot.

17. The method of claim 6, wherein said at least one alternative available time for the reservation is signalled by means of at least one element selected from the group consisting of reservation period, reservation offset, reservation period offset, reservation duration, bitmap (1105) having at least one bit per time slot to indicate the availability of the time slot.

18. The method of claim 2, further comprising the step of implicitly negotiating the reservation using a first beacon frame (400) of the sender device (301) and a first beacon frame (400) of the receiver device (301).

19. The method of claim 1, further comprising the step of including availability information (1105) in a beacon frame (400) of a device (301).

20. The method of claim 5, further comprising the step of the initiator device (301) completing the negotiation with a transmission of a DRP Complete message.

21. The method of claim 5, further comprising the step of the sender device (301) terminating the reservation.

22. The method of claim 21, further comprising the step of a device (301) terminating a reservation that was initiated by an explicit negotiation, by transmission of a termination command (1200).

23. The method of claim 22, further comprising the step of the receiver device (301) acknowledging the termination command (1200) of a unicast stream by transmission of an Immediate Acknowledgment (Imm ACK) frame.

24. The method of claim 22, further comprising the step of sending a termination command (1200) by all devices (301) that had previously included the reservation in a beacon frame.

25. The method of claim 2, wherein the beacon frame (400) of the transmitting and including steps comprises a distributed reservation protocol (DRP) information element (IE) (700) that includes information regarding the position of at least one reservation (707) in the superframe (100).

26. The method of claim 22, further comprising the step of terminating a reservation by performing one of the substeps selected from the group consisting of:

removing the reservation IE from a current beacon frame (400) and all subsequent beacon frames (400), and

setting the duration (706) (712) field of the reservation IE (700) to zero in a current beacon frame (400) and removing the reservation IE (700) from subsequent beacon frames (400).

27. The method of claim 1, wherein:

the transmitting step includes in the beacon frame (400) information of a reservation selected from the group consisting of a starting point (705) (711) and duration (706) (712), and a bitmap (708) (712); and

the including step is optional.

28. The method of claim 1, further comprising the step of respecting the reservation by all devices (301) receiving a beacon frame (400) that includes the reservation.

29. The method of claim 1, further comprising the steps of:
including information on a direction of the planned transmission in the beacon frame (400); and
only devices (301) within a transmission range of a receiver device (301) respecting the reservation, in case of a unidirectional planned transmission.

30. The method of claim 25, wherein only the receiver device (301) performs the including step to include the reservation IE (700) in the beacon frame (400).

31. The method of claim 25, wherein only receiver devices (301) and all 1-hop neighbor devices (301) of receiver devices (301) perform the including step to include the reservation IE (700) in the beacon frame (400).

32. The method of claim 25, wherein the sender device (301), receiver devices (301), and all 1-hop neighbor devices (301) of the sender device (301) and receiver devices (301) perform the including step to include the reservation IE (700) in a beacon frame (400).

33. The method of claim 27, further comprising the receiver device (301) of a reservation performing the steps of:

- in case of a Soft Reservation, starting an own transmission if the sender device (301) does not use the reserved time;
- in case of a Hard Reservation, not accessing the medium if the sender device (301) of the planned transmission does not use the reserved time; and
- in case of a Beacon Period Reservation, reserving the time for beacon transmission only.

34. A communications network (300) including a plurality of devices (301) that include reservations for planned transmissions in their beacon frames (400) by performing the decentralized medium access control method of claim 1.

35. A wireless device (301) that reserves the medium (310) in a distributed manner, comprising:

an antenna (307) for sending and receiving messages over a wireless medium (310);

a receiver (302) coupled to the antenna to receive messages transmitted over the wireless medium (310);

a transmitter (306) coupled to the antenna (307) to transmit messages over the wireless medium;

a distributed reservation processing module (304) to perform distributed reservation of the medium (310);

a processor (303) to divide time into a sequence of at least one superframe (100), each said superframe (100) having at least one beacon period (101) that starts at a target Beacon Period Start Time (BPST) (201) and includes at least one beacon slot, said beacon period (101) being followed in the superframe (100) by a data transmission phase (102), and coupled to:

- i. the transmitter (306) and the receiver (302) to send and receive, respectively, beacon frames (400) during said beacon period (101) and data during said data transmission phase (102) of the superframe (100),
- ii. the distributed reservation processing module to
 - a. manage beacon slot occupancy and data transmission phase reservations;
 - a. format a beacon frame (400) for transmission in the at least one beacon slot, such that the beacon frame includes a reservation of the medium by the device for data transmission during the data transmission phase (102), and
 - b. format a beacon frame (400) for transmission in the at least one beacon slot that responds to reservations received over the medium (310).

36. The wireless device (301) of claim 35, wherein:
each superframe (100) further comprises a plurality of medium access slots allocated between said beacon period (101) and said data transmission phase (102);
and further comprising
- a. a bitmap (305) operably connected to said processor (303) and arranged to have at least one bit that corresponds to a slot of said plurality of medium access slots, and
 - b. a memory (308) operably connected to said processor and arranged to store a reservation table of all planned reservations received or sent by the device (301); and
- said distributed reservation protocol (DRP) processing module (304) further configured to
- a. set and reset said at least one bit of said bitmap (305) in accordance with reservations of the medium for data transmission and beacon slot occupancy, and
 - b. store and delete reservations sent and received by the device in the reservation table of the memory (308).

37. A wireless device (301) for distributed reservation of the medium, comprising:
- an antenna (307) for sending and receiving messages over a wireless medium (310);
a receiver (302) coupled to the antenna (307) to receive medium reservation messages transmitted over the wireless medium (310);
a transmitter (306) operatively coupled to the antenna (307) to transmit medium reservation messages over the wireless medium (310);
a distributed reservation processing module (304) to perform distributed reservation of the medium; and
a processor (303) coupled to the distributed reservation processing module (304), a distributed reservation protocol (DRP) bitmap (305), and a memory including a DRP reservation table (308), said processor to perform the decentralized medium access control method of claim 1 using the distributed reservation processing module (304), the DRP bitmap (305), and the DRP reservation table (308).